Physics 51 "Study Guide" for Midterm 1 ("Laundry List" of important concepts) Todd Sauke

Concept (important **concepts** in **bold; vectors** also shown in **bold**)	**Symbol or Equation**
Prerequisites:	
Physics quantities are typ. either scalars or **vectors** (magnitude & direction)	*components* of vectors add
From **mechanics**, total external **force** on a body = mass x acceleration	$\Sigma \mathbf{F}_{ext} = m\,\mathbf{a}$ (SI newton, "N")
Mass (SI kilogram, "kg") resists change in motion (via "**momentum**", **p**)	$\mathbf{p} = m\mathbf{v}$, $\mathbf{F}_{ext} = d\mathbf{p}/dt$
A mass moving in a circle undergoes **centripetal acceleration**	$a_{centr} = v^2 / r$
Conservation of linear momentum: Isolated system ($\Sigma\mathbf{F}_{ext} = 0$) → $\Delta\mathbf{p}=0$; $\mathbf{p}_f=\mathbf{p}_i$	$m_1\mathbf{v}_{f1} + m_2\mathbf{v}_{f2} = m_1\mathbf{v}_{i1} + m_2\mathbf{v}_{i2}$
A moving mass has energy of motion, "**Kinetic Energy**" (SI joule, "J")	$KE = ½\, m\, v^2$ (a scalar)
A spring being compressed pushes back proportional to compression	$\mathbf{F} = -k\,\mathbf{x}$
A compressed spring has energy of compression, elastic "**Potential Energy**"	$U = ½\, k\, x^2$
For conservative forces, mechanical energy is conserved	$E=KE+PE=\text{constant}$ ($W_{nc}=0$)
Electromagnetics:	
Electric Charge is the fundamental quantity in Electrostatics	Q (SI coulomb, "C")
Charge is conserved, quantized, and comes in "positive" and "negative"	$e = 1.602 \times 10^{-19}$ C
Like charges repel (**radially**); opposite charges attract; **Coulomb's Law**	$F = 1/(4\pi\varepsilon_0)\, q_1 q_2 / r^2$
The constant ε_0 is numerically related (by definition) to the speed of light, c	$\varepsilon_0=10^7/(4\pi c^2)=8.854\times10^{-12}$
All "normal" matter is made up of **protons, neutrons** and **electrons**	Coulomb's $k=1/(4\pi\varepsilon_0)=8.99\times10^9$
Protons have +e charge; electrons have –e. Their mutual attraction holds	$m_p = 1.67 \times 10^{-27}$ kg
everything together. In a conductor, electrons are free to move around.	$m_e = 9.11 \times 10^{-31}$ kg
Total force (**vector**) is the vector sum of individual forces (**superposition**)	$\mathbf{F} = \Sigma\, \mathbf{F}_i$
The Electric field vector is the force per unit charge on a "test charge", q_0	$\mathbf{E} = \mathbf{F}_0 / q_0$ $\quad \mathbf{F} = q\,\mathbf{E}$
For distributions of charge (eg. λ, σ), vector integrate over the distribution	$\mathbf{E} = \int d\mathbf{E} = \int dq/(4\pi\varepsilon_0 r^2)\,\hat{\mathbf{r}}$
Field lines provide a graphical **representation** of **E** (and **B**) fields	E strong where lines are dense
An **Electric Dipole** is a separation of equal magnitude, opposite charges	$\mathbf{p} = q\mathbf{d}$ (**d**=separation - → +)
An Electric Dipole, **p**, in an Electric field, **E**, experiences a torque	$\boldsymbol{\tau} = \mathbf{p} \times \mathbf{E}$ $\quad \tau = p\,E\sin(\phi)$
An Electric Dipole oriented in an Electric field has potential energy, U	$U = -\mathbf{p}\cdot\mathbf{E} = -p\,E\cos(\phi)$
Electric Flux; "flow" of **E** through a surface. (d**A** is a **vector** ⊥ to surface)	$\Phi_E = \int \mathbf{E}\cdot d\mathbf{A}$ (through surface)
Gauss's Law expresses the fact that the source of (static) flux is charge	$\Phi_E = \oint \mathbf{E}\cdot d\mathbf{A} = Q_{encl} / \varepsilon_0$
Charge on a conductor at rest resides on its *surface*. Also for conductor→	$\mathbf{E}_{inside} = 0$ (for **static** case)
Use Gauss's Law to determine **E** field for **symmetric** charge distributions	eg. $E = \sigma / 2\varepsilon_0$ (for sheet)
Gauss's Law easily shows E from a line of charge (instead of nasty integral)	$E = \lambda / (2\pi\varepsilon_0 r)$
A symmetric distribution will be easier to solve for E using Gauss's Law	eg. $E=\sigma/\varepsilon_0$ (between two cond. plates)
Electric force from a **static** charge distribution is a **conservative** force	
Work done on "test charge" is path-independent change in **potential energy**	$U=qV$ $\quad U=q_0/(4\pi\varepsilon_0)\Sigma q_i/r_i$
Electric Potential is potential energy per unit charge (SI volt, "V")	$V=U/q$ $\quad V=1/(4\pi\varepsilon_0)\Sigma q_i/r_i$
We always speak of "**potential difference**" (the zero is chosen for convenience)	$V_a - V_b = \int \mathbf{E}\cdot d\mathbf{l}$
The reverse of this is that **E** field is the (minus) gradient of the potential	$\mathbf{E} = -\,\textbf{Grad}\,(V)$
Equipotential surfaces are everywhere perpendicular to the E field lines	
A **capacitor** (any pair of separated conductors) holds charge per volt	$C = Q / V_{ab}$ (SI farad, "F")
Capacitance depends ONLY on geometry (& what's between conductors)	$C = \varepsilon_0 A / d$ (parallel plates)
When capacitors are connected in **parallel**, the **equivalent capacitance** is:	$C_{eq} = C_1 + C_2 + C_3 + \ldots$
When in **series**, capacitors have an **equivalent capacitance** given by:	$^1/C_{eq} = {^1/C_1} + {^1/C_2} + {^1/C_3} + \ldots$
It takes work (energy) to charge a capacitor. W = potential energy, U	$U = ½Q^2/C = ½CV^2 = ½QV$
Energy (U) stored in a capacitor **"resides"** ***in*** **the electric field**	$u = ½\,\varepsilon_0 E^2$ (u = U-density)
If the insulation separating capacitor conductors is dielectric, not vacuum:	just replace ε_0 with $\varepsilon = k\,\varepsilon_0$!